SEMIANNUAL STATUS REPORT

to

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

on

RESEARCH GRANT

NsG-533

COVERING PERIOD APRIL 1, 1966 through SEPTEMBER 30, 1966

Submitted by

West Virginia University

Morgantown

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SEMIANNUAL STATUS REPORT ON NASA GRANT NsG-533/49-001-001

Covering the Period April 1, 1966 through September 30, 1966

On the pages following are descriptive progress statements on each of the space-related scientific and engineering basic research activities supported under this grant and its supplements #1 and #2 which were active during the period covered. The project numbering system follows that of the last semiannual status report (1 through 12) carrying the date May 12, 1966. New projects or second phases of projects are numbered 13 through 24.

Informal notification has been received during the last few days of the granting of supplement #3. This will permit current funding, project selection, and planning on a much sounder basis than last year.

West Virginia University is gratified and appreciative of this grant which, because of its sustaining nature, means so much to the development of new basic research and new research personnel in space-related scientific and engineering fields.

1. CARDIOVASCULAR, RESPIRATORY, AND AUTONOMIC NERVOUS SYSTEM

   RESPONSES TO ACUTE HYPOXIA by Daniel T. Watts

   This project has been completed and a final report is submitted with

this semiannual status report.

2. PRODUCTION OF DISPERSION ALLOYS WITH THE AID OF ULTRASONICS

   by Harold V. Fairbanks

   This project has been completed and a final report was submitted

on September 7, 1966.

3. AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF HYPERVELOCITY IMPACT

   ON METALLIC CELLULAR STRUCTURES by Emory L. Kemp

   This project is being conducted in phases of which the completion of

the first was described in the report by the same title by Donald L.

Cunard and E. L. Kemp, Civil Engineering Studies Report No. 1001, West

Virginia University previously submitted. The second phase is reported

herein as project 14.

4. EFFECT OF ENDOCRINES ON THE OSTEOPOROSIS OF DISUSE by Hugh A.

   Lindsay

   The Semiannual Status Report of May 12, 1966 included what was

essentially the final report on this project. A second project by Dr.

Lindsay in a related area is reported herein as project 15.

5. ELECTRIC FIELDS AND CALCIUM MOBILITY IN BONE by James H. McElhaney

   This project has been completed and a final report is submitted with

this semiannual status report along with five copies of reprints of an

article from the Journal of Applied Physiology as a condensed version

entitled "Dynamic Response of Bone and Muscle Tissue".

6. REACTION OF Sn(II) AND Sn (IV) in AQUEOUS SOLUTION

by Armine D. Paul

This project has been completed and a final report was submitted with the last semiannual status report dated May 12, 1966.

7. PREPARATION OF as-TRIAZINE (1,2,4,-TRIAZINE) AND RELATED COMPOUNDS by Peter Popovich

A previous progress report indicated that when the 3-tosylate of 5-phenyl-1,2,4-triazine was reduced with lithium aluminum hydride a substance corresponding to $C_9H_9N_3O$ was obtained. It has now been shown that this substance is 3-hydroxy-5-phenyl-4,5-dihydro-1,2,4-triazine. This substance was characterized using elemental analysis, infrared and nuclear magnetic resonance spectroscopy. Furthermore lithium aluminum hydride reduction of 3-hydroxy-5-phenyl-1,2,4-triazine produced the identical 4,5-dihydro compound.

An attempt to reduce 3-hydroxy-5-phenyl-1,2,4-triazine with sodium borohydride to the 4,5-dihydro compound was also conducted. A solid was obtained which is not identical with the product from the lithium aluminum hydride reduction. At present this solid is unidentified.

The previous progress report indicated that 3-amino-1,2,4-triazine was being hydrolyzed with 10% potassium hydroxide solution and that a possible tautomeric enol-keto system may exist. This work has been continued and at present two products have been insolated. One is a solid and the other is an oil. The solid has been identified as 3,5-dihydroxy-1,2,4-triazine. This was characterized by melting point, infrared and by mixed melting point with an authentic sample of 3,5-dihydroxy-1,2,4-triazine. The oil is still under investigation.

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Various attempts to synthesize the parent 1,2,4-triazine with the cyclization of glyoxal with hydrazine and formamide has led to polymers or unidentifiable oils.

A possible route to the parent 1,2,4-triazine is through the 3-bromo-1,2,4-triazine. It was hoped that this compound could be prepared by forming the perbromide salt of the triazine ring, diazotizing the 3-amino group and then replace the diazo group with bromine. This occurs when the excess bromine is neutralized with sodium hydroxide. This reaction with 3-amino 1,2,4-triazine terminated when one third of the calculated amount of sodium hydroxide had been added as a very sharp explosion occurred. Another trial resulted in a similar explosion, completely disintegrating the flasks in both cases. This second trial was run between -10 to -20°C. and nearly two thirds of the calculated sodium hydroxide had been added. A solid formed near the top of the reaction mixture and it appears that this was the source of the explosion. It may be such that the solid dried slightly and was exposed to atmospheric oxygen.

Because of the explosions, the 3-amino compound was abandoned in favor of a more stable substrate, namely 3-amino-5-phenyl-1,2,4-triazine. No undesirable side explosion occurred with this reaction and a small amount of a substance was obtained which may be the 3-bromo-5-phenyl-1,2,4-triazine. This is currently being repeated to obtain a suitable amount of this compound for characterization.

Currently, several thiation experiments are being carried out on the hydroxy derivatives with phosphorus pentasulfide. These include the 3-hydroxy-5-phenyl-1,2,4-triazine, 3-hydroxy-6-phenyl-1,2,4-triazine, 3,5-dihydroxy-1,2,4-triazine, and the 3-hydroxy-1,2,4-triazine. This reaction

will lead to the replacement of the hydroxyl groups with thiol, which in turn we will attempt to replace by hydrogen by Raney nickel reduction.

It is hoped that the work can be completed before January 1, 1967 and a final report submitted soon thereafter.

8. DEVELOPMENT OF CONSTITUTIVE EQUATIONS FOR NUCLEAR GRAPHITE FOR SPACE APPLICATIONS (I) by Robert D. Snyder

This project has moved into the second phase of support (II) and progress is reported under project 17.

9. THE PARAMAGNETIC SUSCEPTIBILITY OF LITHIUM AND SODIUM MEDAL by William E. Vehse

This project has been completed and a final report was submitted with the last semiannual status report dated May 12, 1966.

10a. SHOCK TUBE USAGE AS A LOW-COST WIND TUNNEL by Richard E. Walters

Shock Tube Test firings have continued during the report period. Calibration of delay circuits and preamplifier gains, and evaluation of diaphragm materials have been emphasized. Pressure transducers have allowed measurements in the dump tank (test section) and determination of tank and window pressures. A schlieren optical system has been completed and aligned for use.

Progress is slightly behind schedule due to delays in machining the schlieren parts. This time may possibly be made up in the next few weeks.

The next few weeks will see the initiation of data collection which will cover most of the project objectives. A graduate assistant and an undergraduate assistant will be employed to speed the work.

A summary of the results will be submitted to a national journal at the conclusion of the project. A more detailed report will be prepared for local use and to provide data to interested inquierers.

Several probable areas of continuing work have been recognized. Included are transonic testing, high Reynolds number testing and detailed wake studies.

Students involved in this work currently are one undergraduate, seeking a BSAE degree, who will do an independent paper on some selected area of the project. A graduate assistant is aiding with the work, seeking a MSAE degree, and has not yet selected a definite thesis subject, but will do his thesis in this area. The principal investigator will use some of the project work as the basis for a Ph.D. dissertation, which will emphasize high Reynolds number-subsonic testing in the shock tube.

10b.   AN EXPERIMENTAL STUDY OF VISCOUS-FLOW NOSE-SHAPE EFFECTS ON IMPACT TUBES by Richard E. Walters

This project has been completed and the final report was submitted on June 10, 1966.

11.   DISSOCIATION EFFECTS ON SPHERICAL BURSTS by Nathan Ness

This project was completed on May 31, 1966 and reported as noted below.

The problem involved determining the state of the air between an expanding spherical piston and a spherical shock wave, including in the analysis chemical effects.

The equilibrium and frozen chemistry investigations were completed prior to this period. During this latest period nonequilibrium chemical effects on the flow properties were considered. This was still under investigation when the project ended.

NSF has provided funding for one year to expand on the seed money analysis. Funding provides for the principal investigator and two graduate research assistants.

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Two master's theses in the Department of Aerospace Engineering were completed on this project prior to the latest reporting period and copies submitted in lieu of a final report. They were:

Spherical Bursts including Effects of Equilibrium Chemistry by Donald J. Bennett (1965).

Frozen Flow Effects on Spherical Bursts into an Ambient Quiescent Atmosphere by James R. Hess, Jr. (1966).

Mr. Bennett received his master's degree in 1966 and is now working for the Boeing Company, Seattle, Washington on fluid flow problems.

Mr. Hess received his master's degree in 1966 and is now a candidate for the Ph.D. degree in the Department of Aerospace Engineering where he is also a part-time instructor.

12. PRELIMINARY RESEARCH ON GONEOMETRIC AND CRYOGENIC RADIATION PROPERTIES;

   AND THE MATHEMATICAL ANALYSIS OF LOUVER CONTROL FOR SPACECRAFT

   by Jerome F. Parmer

This project has been completed and a final report is submitted herewith which is essentially in the form of a proposal for separate funding by NASA of a continuation of certain aspects of the preliminary work. The title of the proposed study is "The Experimental Determination of The Thermal Absorptance And Emittance of Spacecraft Surface Temperature Between Cryogenic And Ambient Temperatures". It was submitted on July 14, 1966. It is based on the analytical evaluations of a method to determine the thermal radiation properties of spacecraft materials at cryogenic temperatures. The proposal as a final report incorporates error analysis and equipment evaluations which were performed subsequent to the work reported in the last status report bearing the date of May 12, 1966.

13. NULL GRAVITY SIMULATOR by Robert W. Shreeves

This project has been terminated due to the resignation of Dr.
Shreeves. As noted in the last semiannual status report dated May 12,
1966, the investigation resulted in negative findings concerning develop-
ment of the project subject. Dr. Shreeves is reported to be presently on
the staff at Georgia Institute of Technology.

14. THE EFFECT OF SIMULATED METEOROID BOMBARDMENT ON METALLIC CELLULAR

     STRUCTURES by E. L. Kemp

This is the second phase of project 3 of this report and was initiated
on September 1, 1966. Mr. R. Long is acting as Dr. Kemp's research assist-
ant. The results of the study will be used by Mr. Long as the basis for an
M.S. thesis.

Following the successful development of the high velocity light gas
gun, the purpose of the second phase of the program is to modify the gun
so that velocities of 18,000 to 20,000 ft./sec. can be obtained. The
present facility is limited to approximately 11,000 ft./sec. which is below
the range desired to simulate meteoroid impact. It is expected that the
modification will be completed by January 1967, and the panel testing
completed before the end of the spring semester.

The project has two main objectives, namely, to improve the capability
of the light gas gun for present and future research and to provide detailed
data on the effect of hypervelocity impact on structural honeycomb using the
initial pilot study as a basis for the work.

Commander D. L. Cunard, USN was responsible for the execution of the
first phase of the program and his work resulted in a M.S. Thesis and a
jount report[1] which was submitted to NASA. Commander Cunard has been

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[1] "Experimental Investigation of the Effect of Hypervelocity Impact on
Metallic Cellular Structures", by Donald L. Cunard and E. L. Kemp. West
Virginia University, Morgantown, West Virginia, 1966.

assigned to aircraft research and development with the Navy and should find his research and course work at West Virginia University useful in his present position.

Since the project has just started the only expense incurred to date is the monthly stipend for Mr. Long for the month of September.

With the completion of this project the information will be presented for publication and a complete detailed final report submitted to NASA. In addition, the information obtained and procedures developed in the current series will provide the basis of proposals for more complex research in this field.

15. CIRCADIUM RHYTHM IN TOXICITY by H. A. Lindsay

This period has been occupied chiefly with the completion of construction of apparatus, followed by testing of same. Apparatus for control of lighting to simulate dawn and dusk has been completed and tested, as has apparatus for the measurement of sound production as an indicator of animal activity. The project is now at the point where it is feasible to begin to relate drug toxicity, and activity of the animals, as these two interact and as they are influenced by natural and unnatural light cycling. One can not yet offer, at this early phase of the project, an opinion as to its ultimate scope. Results to date are encouraging however and the project is being actively pursued.

16. INFLUENCE OF COSMIC FACTORS ON THE VIRULENCE OF <u>CANDIDA ALBICANS</u>
      by A. E. Morehart

Study of the influence of cosmic factors on the virulence of <u>Candida
albicans</u> was begun as shown in the flow chart below. Briefly, the work
has proceeded as follows: (1) each Candida strain was tested for virulence
(2) strains were exposed to irradiation or inoculated into rats for simulated
high altitude stress (3) possible alteration in virulence was assessed by a
second virulence test.

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                          C. Albicans
                               |
                               v
                         Virulence Test
                             | |
      Irradiation -<---------  ----------->- Altitude Stress
           |                                      |
           -------------->- Virulence Test -<------
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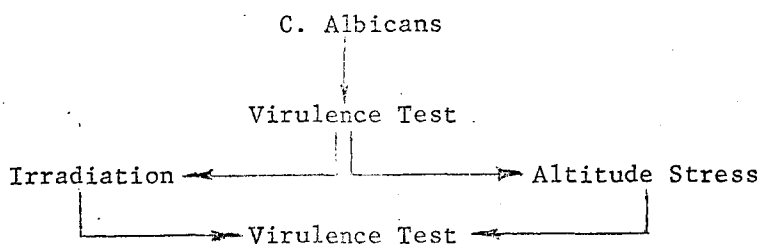
SUMMARY OF EXPERIMENTS

Virulence Test

Virulence tests were initiated on 14 strains of <u>Candida albicans</u>. The
origin, source and relative virulence of each strain are shown in Table 1.
Preliminary study indicated that the customary criterion for estimating
virulence, i.e., death of experimental animals (LD_{50}) was not applicable
with <u>C. albicans</u> strains. Organ invasion and persistence of the fungus was
found to be a more reliable means of assigning relative virulence. Sus-
pensions of 10^4 , 10^5 , and 10^6 yeast cells were inoculated intravenously
into each of 5 adult female mice. The animals were necropsied after 14 days.
Blood, liver, kidney, and pancreas were removed and cultured for <u>C. albicans</u>
on glucose-yeast extract agar supplemented with antibiotics. Portions of
each organ were fixed in formalin, sectioned and stained for microscopic
examination. In some instances sections were made from quick-frozen tissue
for immediate examination. Each strain was then classified according to

relative virulence in one of the following categories: (1) avirulence - absent in tissues and cultures; (2) low virulence - present in one organ; (3) medium virulence - present in one or more organs; (4) high virulence - systemic infection.

Ultraviolet Irradiation

C. albicans yeast cells were harvested from 24-hour-old cultures and suspended in physiological saline. The number of cells were estimated by hemacytometer counts and adjusted to approximately 10,000 per ml. A 10 ml cell suspension was placed in a petri dish positioned 15 cm below a low pressure mercury vapor lamp. The rays emitted were 95% 2735$\overset{o}{A}$ wave length. Total radiant energy was measured with a photoelectric dosimeter in microwatts per square centimeter. A series of exposures were made on a given strain until the dose yielding complete kill was achieved. Typical results of UV exposure are shown in Table 2. Survivors of the exposure preceding total kill were isolated, cultured, and subjected to further UV irradiation. Strain 132, for example, received three such treatments. Subsequently, survivors of the second irradiation were inoculated into mice for virulence tests. Strain 132 was avirulent initially but after two UV exposures the fungus invaded tissue (Table 3). Cells isolated from tissue were once again subjected to UV irradiation. These data are shown in Figure 1 Strain 132 UV_3 cells are smaller than 132 but the physiological characteristics (criterion for speciation) are unchanged.

Infrared Irradiation

Infrared irradiation of C. albicans cells previously exposed to high dosages of UV was neither synergistic nor inhibitory.

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X-ray Irradiation

X irradiation studies are in the preliminary stage. Dosage levels up to 5 kr have not killed C. albicans yeast cells. Further study will require the use of the deep therapy machine so that levels of 10-20 kr can be achieved rapidly. Arrangements are being made for use of this unit.

High Altitude Stress

The extent of organ invasion by C. albicans in animals subjected to the stress of simulated high altitude was studied. White male rats were exposed 8 hours daily to 24,000 ft in an altitude simulation chamber. "Altitude" animals were divided into three groups of six each and twice replicated. Group 1 (preinoculated) was inoculated with 10^4 C. albicans yeast cells prior to high altitude stress; Group 2 (postinoculated) received 10^4 yeast cells after accrual or high altitude stress; Group 3 served as the "altitude" control. Group 1 animals were necropsied one day after accrual of desired stress. Group 2 animals were inoculated one day after accrual of desired stress and necropsied 14 days later. Three animals of Group 3 were necropsied along with Groups 1 and 2. Finally, comparable inoculated and uninoculated nonaltitude animals were necropsied along with Groups 1 and 2. These data are shown in Table 4.

PRESENT STATUS AND FUTURE STUDY PLAN

The most relevant findings thus far are: (1) alteration of an avirulent strain of C. albicans (132) to a virulent strain after extended exposure to UV irradiation; (2) a possible relationship between virulence and resistence to UV irradiation (see Table 1); (3) simulated high altitude stress had little affect on the extent of tissue invasion by C. albicans. Heart tissue appears more prone to invasion in animals inoculated after stress than in preinoculated animals.

Points one and two above will be reexamined in a well replicated and controlled study. Exposure parameters for X irradiation and possibly UV infrared synergists will be established. Optima of all cosmic factors will be contrasted in a randomized black design on selected strains.

PUBLICATION PLANS

There are no immediate plans for presentation of these preliminary findings. Sufficient data should be available for presentation at a meeting in the spring followed by submission of a paper for publication.

PROSPECTS FOR FURTHER FINDING

The conversion of an avirulent strain of C. albicans to one capable of invading tissue may indeed be noteworthy. The significance of this finding in relation to space travlers is heightened by a recent report by Riley et al., Aerospace Medicine 37: 821-824. These workers reported that the feces of volunteers feed two space type diets uniformly contained C. albicans. Thus, the virulence alteration and the relationship of UV resistance to virulence may be worthy of further study and support.

STUDENTS INVOLVED IN PROJECT

Anthony Zoffuto - Research Assistant will complete M.S. degree in June. Thesis entitled, "Histochemical Study of Renal Candidiasis."

Table 2. Percent of viable <u>Candida albicans</u> yeast cells after exposure to various dosages of UV irradiation.

Dosage Milliwatts/cm^2

Strain	21.8	43.5	65.2	87.0	108.7	130.5	152.2	188.0
2	*66.7	46.9	24.2	24.2	9.1	4.5	0	0
3	79.8	79.0	46.4	45.0	35.7	35.0	2.4	0
16	77.0	38.5	22.0	6.6	0	0	0	0
132	51.3	44.7	30.3	15.8	7.9	3.9	1.3	1.3
272	67.7	68.0	31.3	25.0	7.8	0	0	0
413	92.0	91.0	87.7	87.0	77.5	77.0	69.4	53.1
919	72.7	66.7	60.6	34.8	27.3	10.6	3.0	3.0
932	95.6	95.0	91.1	80.0	53.3	57.7	35.6	33.3

* Percent viable cells treatment and control.

Table 3. Isolation of C. albicans from mice inoculated with UV irradiated yeast cells.

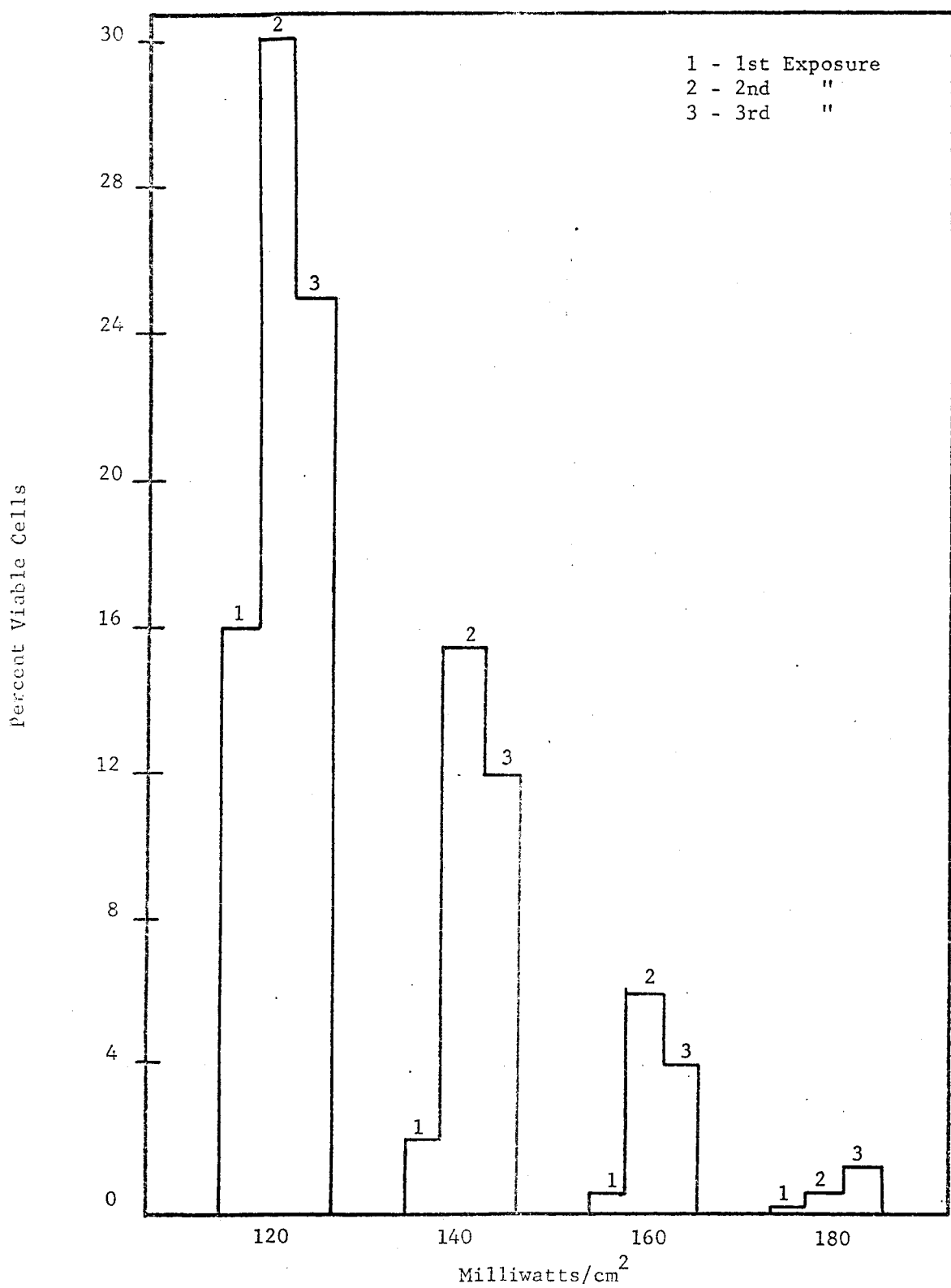| UV Passage	No. Cells Inoculated	Blood	Liver	Kidney	Pancreas
0	$1x10^4$	0/5	0/5	0/5	0/5
	$1x10^5$	"	"	"	"
	$1x10^6$	"	"	"	"
1	$1x10^4$	"	"	"	"
	$1x10^5$	"	"	"	"
	$1x10^6$	"	"	5/5	3/5
2	$1x10^4$	"	"	0/5	0/5
	$1x10^5$	"	"	"	"
	$1x10^6$	"	"	5/5	"

Figure 1.   Survival of C. albicans
(Strain 132) after successive UV irradiations.

Table 4. Isolation of C. albicans in pre- and postinoculated rats subjected to high altitude stress.

Hours Simulated Altitude	Organ Cultured at Necropsy				
	Heart	Liver	Kidney	Blood	Pancreas
(Preinoculated with 10^4 C. albicans)					
0	N	N	N	N	N
40	N/N	N/P	P/P	N/N	P/P
160	N/N	P/N	P/N	P/N	N/N
320	N/N	N/P	P/P	N/N	N/N
640	Incomplete				
Postinoculated with 10^4 C. albicans					
0	N	N	N	N	N
40	N/N	P/P	P/P	N/N	N/N
160	P/P	P/P	P/P	P/P	N/P
320	P/N	N/N	N/N	N/N	N/N
640	Incomplete				

Numerator   - Altitude animals
Denominator - Ground animals
N = Negative culture
P = Positive culture

17. DEVELOPMENT OF CONSTITUTIVE EQUATIONS FOR NUCLEAR GRADE GRAPHITE
FOR SPACE APPLICATIONS (II) by R. E. Snyder

The objective of this project is to develop a general constitutive
equation for the room temperature behavior of nuclear grade graphite which
will enable the design engineer to make efficient and effective use of
graphite as a structural material in aircraft and space vehicles.

The experimental phase of this investigation is nearing completion
and a full report on this work will be submitted shortly thereafter.
Major efforts are now being devoted to the theoretical aspects of this
investigation and a brief description of that work is given below.

This overall project has employed the efforts of six graduate students
at one time or another. From this, one student has already completed his
Master's thesis:

"Electrical Design of High-temperature Induction Furnace" by
Charles Brookes, MSE, Naval Research Laboratory, Washington, D. C.
and two others are nearing completion. In addition, it is anticipated
that at least one doctoral dissertation will emerge from this investigation.

This project has already attracted outside financial support from Los
Alamos Scientific Laboratory and further efforts in this respect are being
pursued.

An extensive critical review has been made of the previous efforts by
other investigators to construct rheological models and constitutive
equations for graphite. Although this review has been hampered by the
fact that some of the most recent work is still classified, it is safe to
say that most of the previous efforts have been rather pedestrian attempts
at curve fitting of one-dimensional stress-strain data. Two theories,

Cottrell's and Jenkins', which attempt to describe the mechanical response of graphite have led to some degree of success in constructing mathematical models for graphite. Both of these theories are based on some sort of dislocation and plastic flow theory for crystals. However, neither of these has yielded a general constitutive equation for graphite and both have shown discrepancies with experimental data.

We have decided to attack this problem using the precise formalism of the mechanics of continuous media. We will attempt to formulate a constitutive equation for a simple material with memory but which is time independent, i.e., a material whose response depends on the deformation history but not on the rate at which this history was executed. In addition, we will invoke the principle of fading memory whereby deformations that occurred in the distant past have less influence in deforming the present state of stress than those which occurred in the recent past. Such a formulation can be expressed in the following reduced form

$$R^T(t) \ T(t) \ R(t) = \mathop{F}_{s=o}^{\infty} [C(t-s)]$$

when $R(t)$ is the rotation tensor, $T(t)$ the stress tensor, $C(t)$ the Couchy-Green strain tensor, and F is the constitutive functional whose kernels are the material functions. Our problem will be to evaluate the form of these material functions.

18. THE ENGINEERING FEASIBILITY OF A COMPUTER WITH A HYBRID FLOATING POINT VARIABLE REPRESENTATION by R. E. Swartwout

The principal investigator began active work on this project in mid July, 1966. Although the budget calls for a graduate assistant to join the project in September, this will not be done until January, 1967 to

allow the investigator sufficient time to plan the work.

As anticipated, the initial phase of the work involved a study of the work by Lee at MIT. He designed a system with some similarity to the one under study. The primary differences are that his was a special purpose rather than general purpose; in his system all of the analog units were time shared; and in his system all of the program was controlled by a digital computer. This type of system is interesting enough so that, if possible, the objective of the study will be enlarged to include such a configuration.

Much of the early work has been devoted to a study of the accuracy obtainable with analog and digital elements. Some estimate of the accuracy attainable when using the proposed floating-point system is needed. When this information is reliably determined, the base of the exponent will be selected. In Lee's system a decimal base was used but at times could only obtain results accurate to within 10%. If a different system or a different base cannot improve on this, then the system is not feasible.

Even at this early stage of the research it is apparent that following this task, or concurrent with it, a study should be made into the specific ability of digital computers to do real time computation. This feasibility study has been, and will continue to be, concerned with the non-economic engineering feasibility of a certain configuration of hardware. Only a small portion of the time was allotted to a study of the ability of 3rd or 4th generation digital computers to do real-time computation. If reports of the capabilities of the 4th generation computers are reliable, then the economics of building a totally new system of the type proposed here needs careful examination. I suggest that a study should be initiated

into the specific capabilities of the latest and of proposed digital machines to do real-time computation. It is anticipated that a proposal to this effect will be one of the unexpected results of this project.

19. RHEOLOGICAL PROPERTIES OF BONE AND MUSCLE TISSUE

    by James H. McElhaney

The experiments as described in the proposal have been designed and implemented except for a displacement transducer. Because of material shortages attributed to the war, delivery of this item has been delayed. Preliminary experiments on whole femurs have been made, however. A cell for maintaining muscles in a physiological state has been designed and is under construction.

An analogue computer program has been developed that allows rapid evaluation of proposed rheological models and comparison with the data denerated from the above experiments.

Except for purchasing delays, progress has been satisfactory and a successful conclusion of this project is anticipated.

20. THERMAL DECOMPOSITION STUDIES IN THE SOLID STATE by G. L. Humphrey

Actual work on this research project began on June 1, 1966, with the appointment of a research assistant. Preliminary experiments during the past four months have been made to determine experimental procedures and correct methods of approach in carrying out the project.

The following points have been investigated:

1. Methods of sample preparation

    a. Investigation of decomposition upon grinding

    b. Repressing of disks to give higher transmission

    c. Drying of salt matrix Materials

    d. Freeze-drying techniques for dispersion of sample in the matrix material.

2. Alterations in spectrometer system

    a. Cells

    b. Pen recording mechanism

3. Linearity of absorbance versus disk weight

4. Observation of spectral species

    a. Trapping of carbon dioxide in salt matrix

5. Preliminary rate observations

    a. "Equilibrium" effects

6. Purity of materials

    a. Recrystallizations

    b. Titrations

Various methods of sample preparation have shown that grinding samples with the salt matrix material by means of a mechanical grinder results in some decomposition of sample during the grinding process. Grinding the samples by means of a mortar and pestle in a dry box results in a minimum amount of decomposition. However, the most promising technique appears to be a freeze-drying technique which gives samples of small particle size and a fairly uniform dispersion of the samples in the salt medium. This latter technique is still being perfected.

In an investigation of salt materials for the matrices it was found that potassium chloride yielded disks with better spectral characteristics and that the salt was less subject to adsorption of water which results in clouding of the disks and loss of transmission.

To counteract the loss of transmission due to clouding of the disks

it has been found that the disks can be repressed to restore them to their original transparency with essentially no loss of weight.

The difficulty of getting last traces of moisture from the potassium chloride seems to be overcome best by placing the finely ground material under high vacuum at temperatures of approximately 200° for extended periods of time.

A new holder for the thermostated disk heater has been constructed and is being tested for performance in the spectrometer. Experiments are being conducted to investigate the secondary emission effects.

A fine-line pen has been adapted to the recording mechanism of the spectrophotometer thus facilitating the determination of small changes in absorbance with time.

Plots of data have shown that there is a linear relationship between absorbance and disk weight. However, many of the disks crack in two before removal from the dye, and such disks show some variance in the absorbance vs. weight plots.

The major products of decomposition appear from spectral observation to be acetic acid and carbon dioxide. Preliminary results show that the dense potassium chloride matrix may give nearly quantitative trapping of the carbon dioxide released.

Preliminary plots of rate data for malonic acid have disclosed some interesting effects. There is an initial short period of time when the rate of decomposition is much higher than that during most of the reaction time. Eventually leveling off of the rate occurs after which time a change in temperature will produce a new rate with a subsequent leveling-off effect.

Explanations are being sought for the "initial rate effect" as well as the "leveling-off effect". It is postulated that the leveling-off period results from an equilibrium effect, but further work is needed to substantiate this hypothesis. As yet no adequate explanation for the "initial rate effect" can be offered.

Purification of materials for investigation has been in progress. Recrystallizations from appropriate solvents have been made, and sublimation techniques are now being investigated for some of the compounds. Acid-base titrations have been made on malonic acid to determine its purity and the amount of coordinated water. The results show a pure compound with no water present.

It is planned to carry out corresponding studies on substituted malonic acids, salts and esters of malonic acid. The various kinds of suitable salt matrices and their influence on the rate of reaction are yet to be investigated, as well as determinations of reaction stoichiometry, order, rate constants, activation energies and identification of by-products and intermediates. It is hoped that suitable mechanisms may be postulated for the reactions.

As will be noted from Section II above, only the preliminary experiments have been completed to date. As soon as enough results have been obtained to merit publication, they will be presented to NASA for approval of publication in a reputable national journal.

If the anticipated results of this research materialize, then there should be good prospects for additional funding.

One research assistant, Mr. Lowell A. Cosby, has been appointed under this research grant. Mr. Cosby, a graduate student in the Ph.D. program in

chemistry, is working on his dissertation research under this program.
The title for the dissertation will probably be "An Infrared Study of the
Solid State Thermal Decomposition of Malonic Acid and Some of Its Salts
and Esters".

21.   THE EFFECT OF DRUGS ON ORGAN DISPLACEMENT DURING WHOLE-BODY
      VIBRATION IN DOGS by E. F. Byars

      This project is being directed by Dr. E. F. Byars and Dr. James
McElhaney due to the absence of Dr. Richard Coddington.

      A thorough literature search has been made with the purpose of
delineating the important parameters of whole body vibration.

      The experiment has been designed and almost fully implemented.
However, some difficulty has been encountered in instrument procurement
resulting in a delay of actual testing.

      Several dogs have been obtained and are currently being conditioned
prior to chronic implantation of the transducers.

      It is hoped that the required instruments will arrive shortly and
actual testing will begin.

      Much attention has been directed to the construction of restraint
systems and two different systems have evolved. When testing is begun,
a comparison of these two systems will be made.

22.   RELATIONSHIP OF OXYGEN TENSION TO VIRAL DISEASE by B. E. Kirk

      A. Summary of Experiments

            Preliminary investigations regarding this project have centered
mainly around developing a tissue culture system which would be useful for
detecting and quantitating lymphocytic chroiomeningitis (LCM) virus. The

most desirable procedure would be to develop a system wherein visible damage to the cultured cells would develop after infection. Such an effect results with many cell cultures after infection with viruses. However, while LCM virus has the ability to infect a number of different types of cultured cells, the appearance of frank cell damage or cytopathic effect (CPE) has been irregular in our experience. Thus, to develop a technique for demonstrating LCM virus based on the visible damage of infected cells, considerable effort has been given to manipulating the culture system to induce such an effect.

Several investigators have reported that addition of chick embryo extract to cultured cells enhances the appearance of CPE resulting from infection with LCM virus. We have prepared a total of fourteen batches of chick embryo extract for use in cell cultures. Of these, approximately half have exhibited some activity in enhancing CPE. One batch of commercial extract which was tested had no activity at all. Some activity was demonstrated with bovine ascitic fluid. We have routinely prepared extract from embryos taken after nine to ten days incubation which is recommended by a number of references. On one occasion, extract was prepared from embryos 7, 9, and 11 days old. However, no difference in activity could be related to age of the embryo.

Thus far, most work has been done using primary monkey kidney and chick embryo cell cultures. For the most part, the results with one have also been found with the other type of culture. Batches of chick embryo extract which are active in one cell type are also active in the other. Batches without activity in one type are also without activity in the other. When CPE occurs, it generally does so approximately seven days after infection.

This seems unusual since in monkey kidney cells we have shown that virus production is maximal by the third to fifth day after infection. From the work of others, this should also hold true for chick embryo cell cultures.

As a technique for demonstrating LCM virus in monkey kidney cells, we have investigated the ability of this virus to interfere with production of CPE resulting from addition of poliovirus. Using the Armstrong strain of LCM virus which has low virulence for guinea pigs, interference with poliovirus was apparent from the fourth through the eighth day after infection with LCM virus. Thus, prior infection of these cells with this strain of LCM virus prevented the development of CPE as well as depressed synthesis of poliovirus. However, using the WE strain of LCM virus which is highly virulent for guinea pigs, no interfering effect was demonstrable.

Work has only recently begun on the effect of oxygen tension as such on infected cell cultures. In our original proposal we postulated that an increased oxygen tension would have an enhancing effect on the development of CPE. To date we have not tested this system, but on one occation, cells held in an atmosphere of 5% carbon dioxide, 95% nitrogen degenerated after infection while control cells did not. Furthermore, CPE developed in the absence of chick embryo extract. Comparable cultures in a conventional presumably aerobic system did not show this effect. A repeat of this work together with an estimation of the sensitivity of this technique for detecting virus as compared to injecting mice is currently in progress.

In relation to a presumed effect of oxygen metabolism by the infected cell cultures, sodium pyruvate was added with the idea of pushing some steps in the carboxylic acid cycle. However, pyruvate in concentrations from one to ten millimolar had no visible effect in this system.

B. Evaluation of Progress

In the area of developing a tissue culture technique we have had several disappointments. For one, our results using chick embryo extract have been quite irregular. Usefulness of an extract supplement has been irregular enough to tempt us to drop this approach, but frequent enough to give us some additional leads. Although work on changing oxygen tension has just begun, we feel that some effect on infected cell cultures will be demonstrated, and suspect the effect of oxygen tension to be somehow related to the action of chick embryo extract.

Our work using monkey kidney cells has been very profitable. Development of CPE, even irregularly, after infection of these cells with LCM virus has not been reported before. Furthermore, interference with poliovirus has not been reported. Different investigators have found that monkey kidney cells are susceptible to infection with this virus, but even though they looked, they found neither interference nor development of CPE. Our work indicates that timing and medium components were very important in achieving these results.

C. Plan of Work

Using chick embryo cells, it was determined early that the appearance of CPE was more dramatic if the medium on the cells was not changed at the time of infection. However, recent observations have made us question the wisdom of using this technique. On one occasion when the medium was changed on the third day after infection, and CPE developed on the sixth day. Examination of the circumstances connected with this experiment has led us to re-examining the timing of medium changes, and also to examining the effect of increased glutamine on the infectious process.

Furthermore, the normal metabolic pathway from glutamine leads to alpha-keto-glutarate and succinate. In the original proposal, succinate was one of the compounds suggested for testing. The usefulness of this system as a model for the study of effect of oxygen tension and the bio-chemical mechanisms involved has become even more intriguing. We still anticipate considerable additional work using both high and low oxygen tension in relation to infected cell cultures. We have deliberately post-poned similar work with infected mice until more information is available on tissue culture systems. However, facilities for keeping mice in a con-trolled atmosphere is now available, and correlation between infected mice and infected cell cultures will be made.

Much of the work thus far has been based on visual effects on tissue culture cells themselves. Quantitative aspects of virus yield by infected cell cultures have been done only to a limited extent and then by injecting mice. Due to the fact that such tests in mice are fairly expensive, we had neglected many of the quantitative aspects of virus yield hopefully until a tissue culture technique was available. However, we will of necessity need to pursue some of these aspects in spite of the added cost of mice.

We have to date given no given attention to a plaque technique for detecting LCM virus activity. Several authors have stated that for other viruses where development of CPE is marginal, a more dramatic effect can be achieved using the plaque technique. We expect to begin work with this technique in the near future.

One additional factor which appears to be involved in this system is pH. Because of the difficulty in controlling pH with a bicarbonate buffer system, we have not been able to assess the effect of pH on this system.

However, some new buffers which have some very interesting properties have recently been described though not in tissue culture. Preliminary studies with one of them -- HEPES -- indicates that the toxicity is sufficiently low to be useful in tissue culture. We anticipate testing the effect of this buffer on virus yield in our system and hopefully comparing the sensitivity of cell cultures maintained in medium containing this buffer with the conventional bicarbonate buffered medium.

D. Publications

We have already begun assembling our data on the interference effect between LCM and polioviruses for publication. Before publication we want to test some of the materials we have collected for interferon activity and include this data in the publication.

E. Prospects for other Funding

Due to the fact that we have not yet demonstrated what we initially set out to do -- namely, demonstrated a real effect of oxygen tension on the infectious process -- it is still premature to predict the eventual outcome of this project. However, we believe that there is a related effect which can be demonstrated experimentally. The next few months should provide us with decisive answers.

F. Students Involved in the Work

Name	Degree Sought
William J. Brown	Ph.D.
Robert W. Veltri	Ph.D.

Both these students have only recently begun a degree program, and it would be premature to propose a dissertation title. Mr. Brown has been concentrating on some of the aspects of embryo extract in chick embryo cell cultures while Mr. Veltri has done the work using monkey kidney cells.

23. MEASUREMENTS OF YIELDING ZONES AT THE END OF A CRACK AND THE

ANALYSIS OF CRACK-PROPOGATION DATA IN SHEET MATERIALS FOR

AEROSPACE STRUCTURES by Syed Yusuff

The investigation carried out during the period June 1 to September 30, 1966 consists of two parts, and they are as follows:

1. Yielding Zones

The objective is the measurement of yielding zones at the ends of a crack. In four sheet specimens of stainless steel alloy, AM 350 (20% CRT) this measurement has been made by two independent methods. The 20 in. wide specimens having 4-6 in. long saw cuts were loaded in a tensile machine, and the yielding zones were measured by photoelastic method and etching. Each specimen was removed from the machine at three different loads and etched by Fry's reagent. These two methods resulted in identical measurement. At failure the length of zones at each end of the crack attained a length of about 1.5 in. The results are in agreement with the theory.

Mr. A. Howell, a NASA trainee, is assisting in this work. Under the title "Yielding Zones and the Mechanism of Fracture", he will present a part of the work in his thesis toward the Master's degree. Three more specimens of stainless alloy will be tested in the future. Similar tests will be made on specimens of 2024-T3 and 7075-T6. The etching of aluminum alloys is not yet successful. We are trying different reagents. In addition to the methods used for measurement of zones, few specimens will also be strain gauged.

2. Analysis of Crack Propagation Data

All the formulas presented so far by many investigators for rate of crack propagation were reviewed. Three formulas suggested by Valluri,

Denice-Christensen and Forman and presented in the reports listed below
were critically examined.

I.   Valluri, S.R. A unified Engineering Theory of High Stress
     Level Fatigue, Aerospace Engineering, Vol. 20, Oct. 1961.

II. Douglas Aircraft Company, Inc. Notch Resistance and Fracture
     Toughness Characteristics of High Strength Metals ASD-TDR-63-
     494, September 1963.

III. Forman, R. G., Kearney, V. E. and Engle, R. M. Numerical
     Analysis of Crack Propagation of Cyclic Loaded Structure:
     Air Force Flight Dynamics Laboratory Report, Wright-Patterson
     Air Force Base, Ohio.

These formulas and the experimental data contained in NASA TN 4394
and NASA TN -D960 were programmed on IBM 7040 computer. This analysis has
yielded many new results and formulas.

Mr. W. Kaiser, a graduate teaching assistant, is assisting in this
part of the program. He will present this work in his thesis for Master's
degree under the title "Analysis of Crack Propagation Formulas". The work
is not yet finished.

Development of other proposals.

A proposal on "Crack Propagation and Fatigue" involving a new
approach has been completely developed. In a day or two it will be sub-
mitted to the Air Force Flight Dynamics Laboratory, Wright-Patterson Air
Force Base, Ohio with whom we had previous consultation. Beside this,
one or two more proposals will also be developed in due course.

24. REACTION KINETICS OF SOLID-GAS SYSTEMS by C. Y. Wen

The starting date of the subject grant was September 1, 1966. There-
fore, this progress report covers the month of September, 1966. Main
progress made during this period includes the literature survey, the pre-
paration for construction of equipment.

Mathematical analysis of complex solid-gas reactions involving kinetics and diffusion is to be made. Experimental data available from the literatures are to be used to check against the validity of the analysis.

Studies have been conducted to test the accuracy of pseudo-steady state approximation in a moving boundary problem by comparing the pseudo-steady and unsteady state solutions for various reaction models.

Some study was also conducted on a equimolal, pseudo-homogeneous fluid-solid reaction. The effect of non-equimolal reaction on the over-all rate process has been considered.

Although the theoretical analyses of the rate of heterogeneous gas-solid reactions are available in the literatures, they are limited to certain specific conditions. Our primary effort will be directed toward a more general understanding of the heterogeneous reaction of gas-solid systems, viz., a systematic study based on sound mathematical models for more complex reaction systems involving more than one gaseous reactant.

The results obtained will be applied to the actual heterogeneous reactions and attempt will be made to show how the knowledge developed can be used for:

1. Evaluation of the extent of heat transfer and combustion problems encountered during the re-entry of a space object, and

2. Prediction of the rate of reaction of solid rocket fuel.

No facility is included in the present grant. It is planned to submit a more comprehensive proposal to NASA, or other research organizations, for a more substantial financial support so that the present project can

be developed into a larger one including acquisition of actual experimental facilities.

A schematic diagram of the necessary equipment is shown in the attached Figure 1. The essence of the equipment is a high pressure, high temperature, gas-flow thermobalance. It consists mainly of a Sanborn Model FTA-10-B592 Microforce Transducer (T) for solid weight measurement, a Sanborn Model No. 592-100 transducer converter (TE), a Hewlett-Packard No. 721A power supply (PS), and a Moseley Model 680 strip chart recorder (R_1). The thermobalance provides for the gaseous effluent analysis simultaneously with continuously recorded measurement of the mass of the solid in a sample basket (B) which is located in an externally heated reactor (RE).

Shih-Chung Wang, a graduate research assistant and Ph.D. degree candidate is also engaged in this project.

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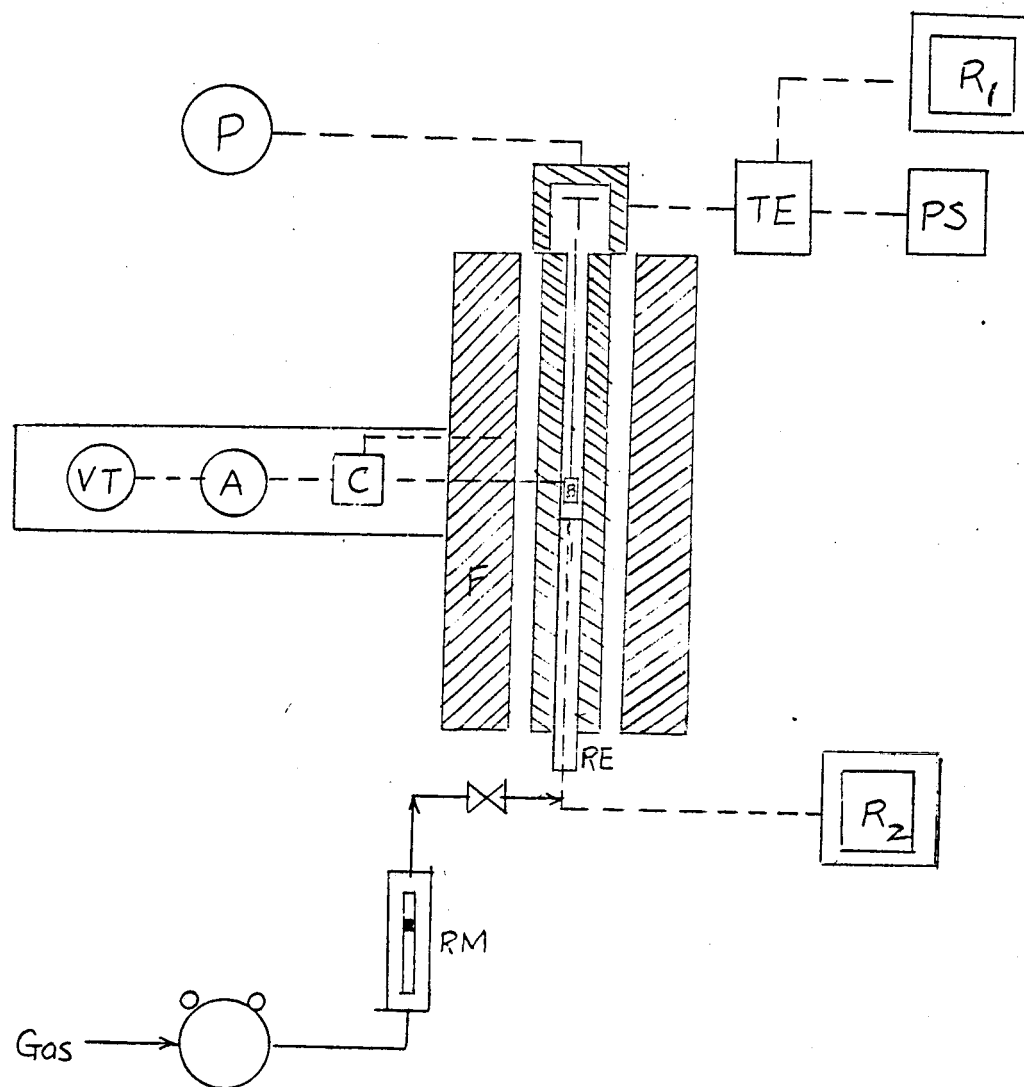| A | AMMETER | | R | RECORDER |
B	SAMPLE BASKET		RE	REACTOR
C	TEMPERATURE CONTROLLER		RM	ROTAMETER
F	ELECTRIC FURNACE		T	TRANSDUCER
P	PRESSURE GAGE		TE	TRANSDUCER EXCITER
PS	POWER SUPPLY		VT	VARIABLE TRANSFOMER

Fig. 1   Schematic Diagram of Equipment